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METHOD AND APPARATUS FOR
WAVELENGTH TUNING OF LIQUID LASERS

A method and apparatus for wavelength tuning and for increasing the conversion efficiency of a liquid laser are disclosed. Wavelength tuning is accomplished by controlling the temperature of the lasing liquid. The invention can be used in the space program for remote probing of the atmosphere.

FIGURE 1 of the drawing shows the apparatus for carrying out the invention, and FIGURE 2 is a graph showing the center lasing wavelength as a function of temperature for four dye concentrations. The apparatus as shown in FIGURE 1 comprises a laser liquid cell 2 containing an organic lasing liquid 1. The cell 2 contains optically polished end windows 5. The temperature is controlled by means of the device labeled 3 in the drawing. The device 3 is a refrigerant cell when the laser is operated at temperatures below the ambient and an oven or heat tape when the laser is operated at temperatures above the ambient. The graph of FIGURE 2 clearly shows that wavelength tuning of a liquid laser can be accomplished by temperature variation. Also, the conversion efficiency of the laser is increased as the temperature is decreased.

The novelty of the invention appears to reside in wavelength tuning of liquid lasers by means that are not mechanical in nature as is the case in the prior art methods. The invention has application in optical communications, in wavelength matching for selective excitation of molecules, in tunable optical sources by optical mixing, and in spectroscopic measurements.

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Fig. 1.

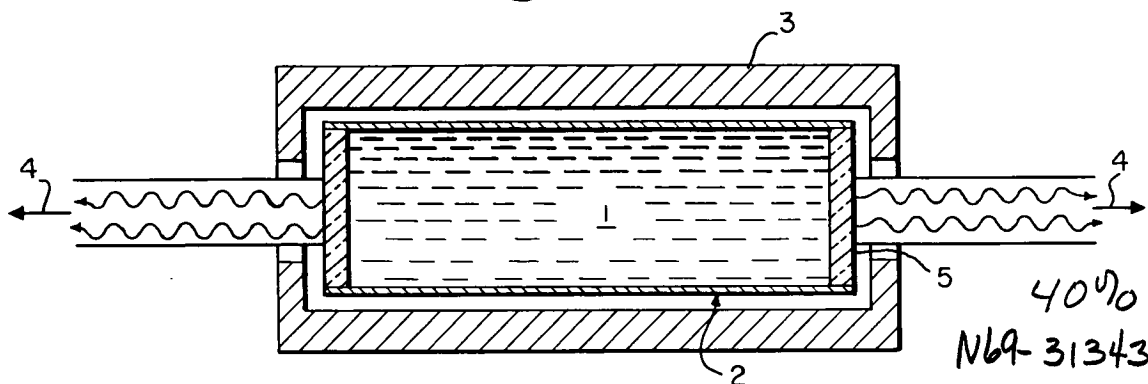
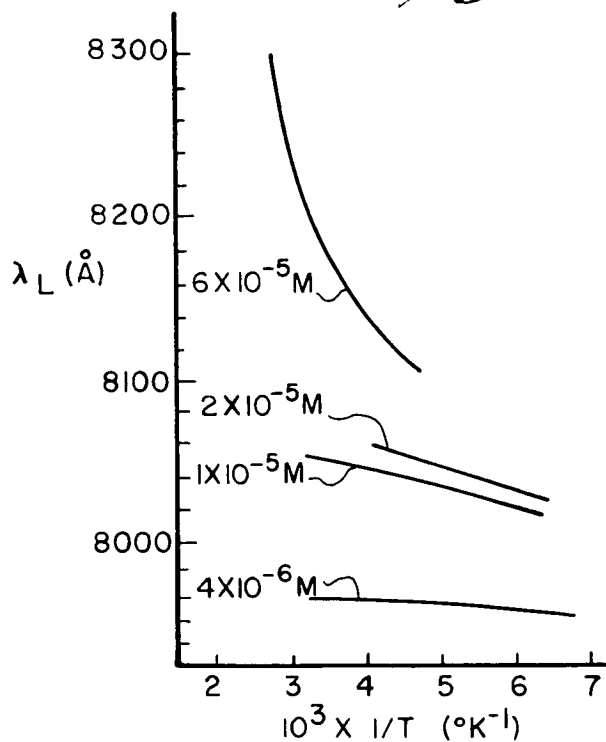


Fig. 2.



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METHOD AND APPARATUS FOR WAVELENGTH TUNING OF LIQUID LASERS

Abstract of the Disclosure

5 A method and apparatus for wavelength tuning and for in-
creasing the conversion efficiency of a liquid laser are disclosed.
The apparatus comprises a liquid cell containing the lasing liquid
and appropriate laser mirrors. The temperature of the cell is con-
trolled to effect wavelength tuning. Temperature control is ob-
tained by surrounding the liquid cell with an oven or heating tape
10 for temperatures above the ambient temperature and by surrounding
the cell with a refrigerant for operation below the ambient
temperature.

Origin of the Invention

15 The invention described herein was made by employees of
the United States Government and may be manufactured and used by
or for the Government for governmental purposes without the pay-
ment of any royalties thereon or therefor.

Background of the Invention

20 This invention relates to wavelength tuning of liquid
lasers, and more particularly, to wavelength tuning of liquid
lasers by temperature variation.

Applications wherein it is useful and highly desirable
to have wavelength tuning of an organic dye laser are in wavelength
matching for selective excitation of molecules, in optical com-
25 munications, in spectroscopic measurements, and in tunable
optical sources by optical mixing. And conversely, by measuring
wavelength, temperature can be measured; hence, the device can be
used as a thermometer.

30 Prior art tuning of liquid lasers has been accomplished
by mechanical means. For example, tuning has been obtained by

variation of the cavity Q and/or by changing the nature or concentration of the lasing medium. These methods have the disadvantage of being purely mechanical in nature.

Summary of the Invention

5 The present invention is directed to a method and apparatus for wavelength tuning of a liquid laser. The tuning is nonmechanical in nature and is accomplished by changing the temperature of the lasing liquid. The temperature changes can be achieved electrically. Therefore, no mechanical changes are
10 necessary. The laser can be operated at temperatures above the ambient temperature or at temperatures below the ambient temperature. In other words, tuning is obtained by heating and/or cooling the lasing liquid.

15 An object of the invention is to provide a method for wavelength tuning of liquid lasers.

 Another object of the invention is to provide apparatus for wavelength tuning of liquid lasers by temperature variation.

20 A further object of the invention is to provide a method and apparatus for improving the conversion efficiency of liquid lasers.

Brief Description of the Drawings

25 The above mentioned and other objects of the invention will become readily apparent from the following detailed description of the invention when read in conjunction with the annexed drawing wherein:

 FIGURE 1 is a schematic representation of the apparatus of the invention; and FIGURE 2 is a graph showing the temperature tuning, that is, the center lasing wavelength as a function of temperature for four dye concentrations.

Description of the Preferred Embodiment

Referring now to FIGURE 1, a liquid laser cell 2 (typically, a stainless steel optical dewar) is shown containing a lasing liquid 1. The ends of cell 2 comprise a pair of optical windows 5 which serve as laser mirrors and as windows for transmitting the radiation out of the cell. The surfaces of each window 5 of the cavity are optically polished and reflect about 4% of the radiation back into the cell. This small reflection is sufficient for lasing action because of the high gain of the medium. The cell 2 is surrounded by the temperature controlling apparatus 3. If the laser is to be operated above the ambient temperature, the temperature controlling apparatus 3 will be an oven or a heating tape that surrounds the cell as shown. If the temperature is to be below the ambient temperature, the apparatus 3 will be a cell containing a refrigerant. Of course, the apparatus can be so arranged that an oven or refrigerant cell are interchangeable. In this manner any temperature variation can be obtained. For example, the laser can be operated at extremely low temperatures by using cryogenic liquids as the refrigerant. Of course, the laser can also be operated at high temperatures by controlling the temperature of the oven or heating tape surrounding the cell 2.

Apparatus for pumping the laser is not shown in the drawing. However, any suitable well-known pumping technique can be used. The apparatus shown in FIGURE 1 has been successfully longitudinally pumped with a ruby laser beam one square centimeter in area at a small angle (22°) with respect to the dye cavity axis.

By varying the temperature of the lasing fluid, the wavelength of the signal output of the laser is also varied. The wavelength spectrum of an organic dye laser pumped by a Q-switched ruby laser has been measured as a function of temperature for several dye concentrations. The laser liquid used was diethylthiatricarbocyanine iodide in ethanol and the temperature was varied from -117°C to $+78^{\circ}\text{C}$. The results of these tests, as shown in FIGURE 2, clearly show that wavelength tuning of a liquid laser can be accomplished by temperature variation. Furthermore, these tests have shown an increase in conversion efficiency by a factor of three as the temperature was decreased from 20°C to -60°C .

While the invention has been discussed with reference to a preferred embodiment, it will be obvious to those skilled in the art that various changes and modifications to the invention can be made without departing from the spirit or scope of the invention. For example, the laser cell itself need not be constructed exactly as shown in the drawing of the cell. However, the cell must be so constructed that temperature controlling means can be readily coupled to the cell without interfering with the operation of the laser.